



Armed Forces College of Medicine AFCM



Digestive System

GIT

introduction

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INTENDED LEARNING OBJECTIVES (ILO)



**After studying this, you should
:be able to**

Describe the **functions** of the digestive -
system

- List the **four basic digestive
processes:**

motility, secretion, digestion and)
.(absorption

Explain the main **control mechanisms** -
:for digestive processes

autonomous smooth muscle function,) intrinsic nerve plexuses extrinsic nerves



Lecture Plan



1. Part 1 (5 min) **Introduction to the four basic digestive processes**
2. Part 2 (35 min) **Main lecture: Control mechanisms of digestive processes**
3. Part 3 (5 min) **Summary**
4. **Lecture Quiz** (5 min)

:Digestive system consists of

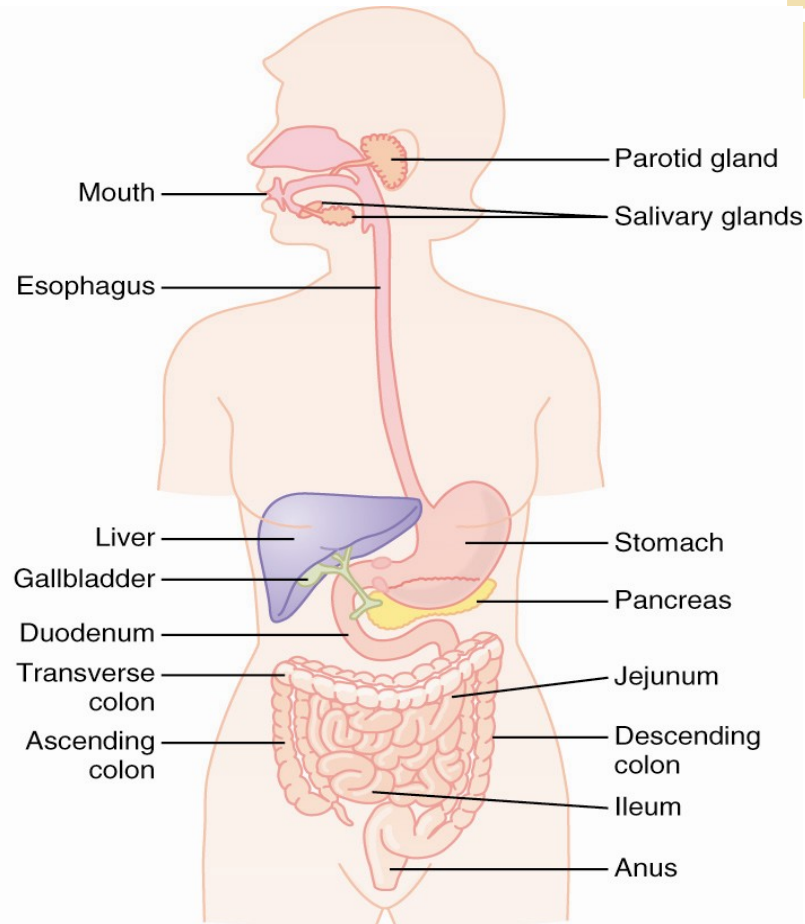
Digestive tract =
Gastrointestinal
= tract
Gut = Alimentary
canal

Accessory
digestive

- salivary glands

exocrine pancreas

- liver &
gall
bladder



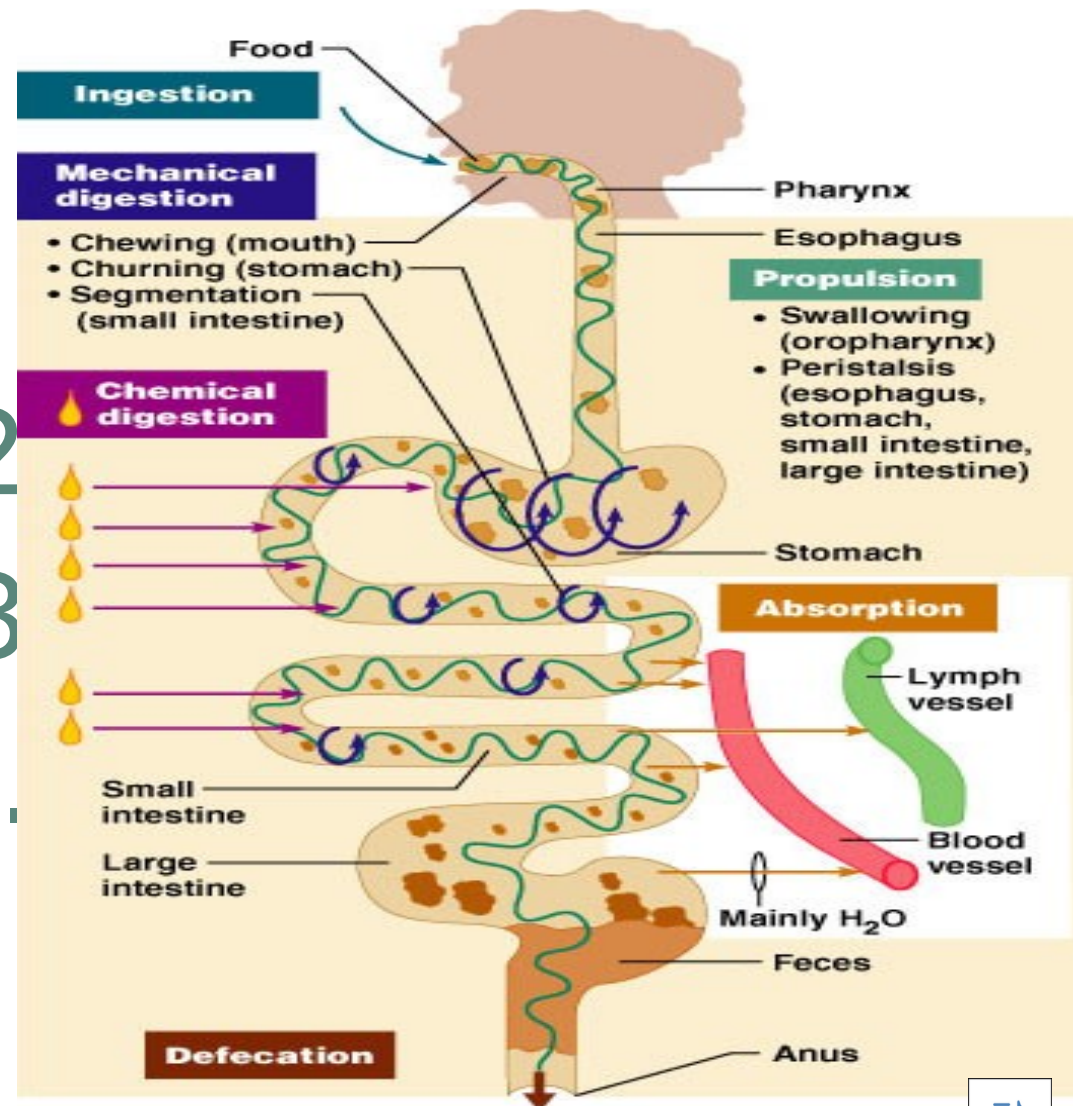
Function of the digestive system is performed by **four basic digestive processes**

Motility .1

Secretion .2

Digestion .3

Absorption .4



Excretion= Elimination of un-digested



Motility (1)

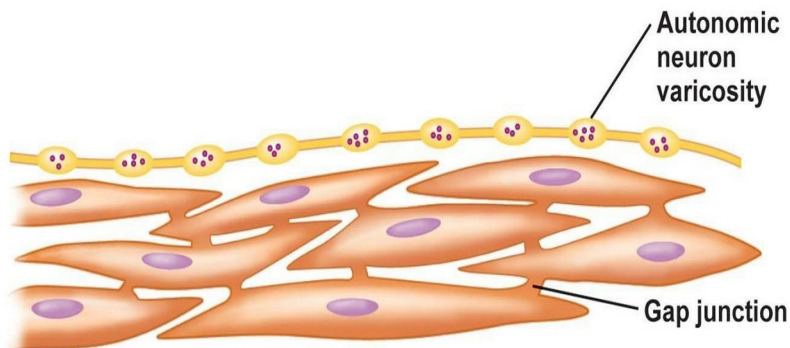
✓ **Definition:**

The muscular contractions that **mix** and **move** forward the contents of the digestive tract

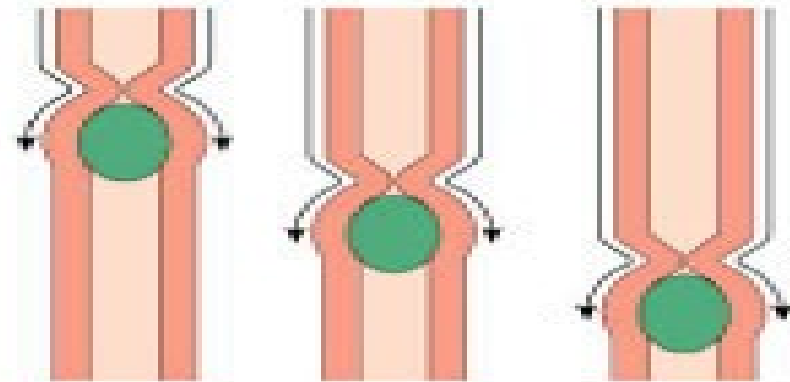
✓ **Types:** There are **2** types:

(a) Propulsive movement

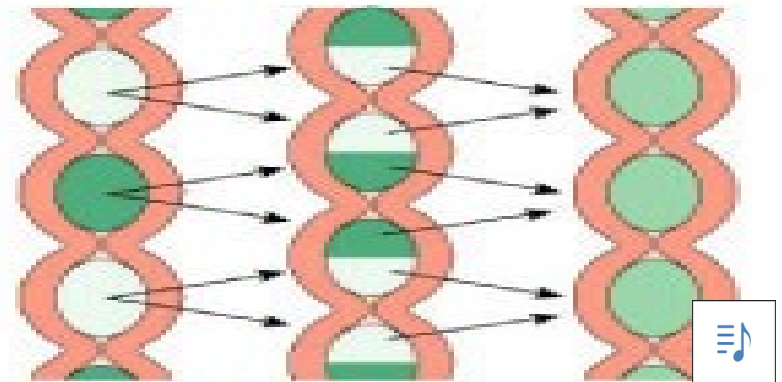
(b) Mixing movement



(b) Single-unit smooth muscle



(a)



(b)

Motility (1)

Propulsive movements:

They propel (push) the contents forward through the -
.digestive tract at varying speeds

The **rate** of propulsion depends on the function of the -
∴different parts. **e.g**

□ **Esophagus**: is a passageway for food from mouth to
.stomach. So, transit of food through it is very rapid

□ **Small intestine**: is the major site for digestion and
.absorption. So, the contents are moved slowly

The basic propulsive movement of the GIT is -

.**peristalsis** that occurs in all parts of the GIT



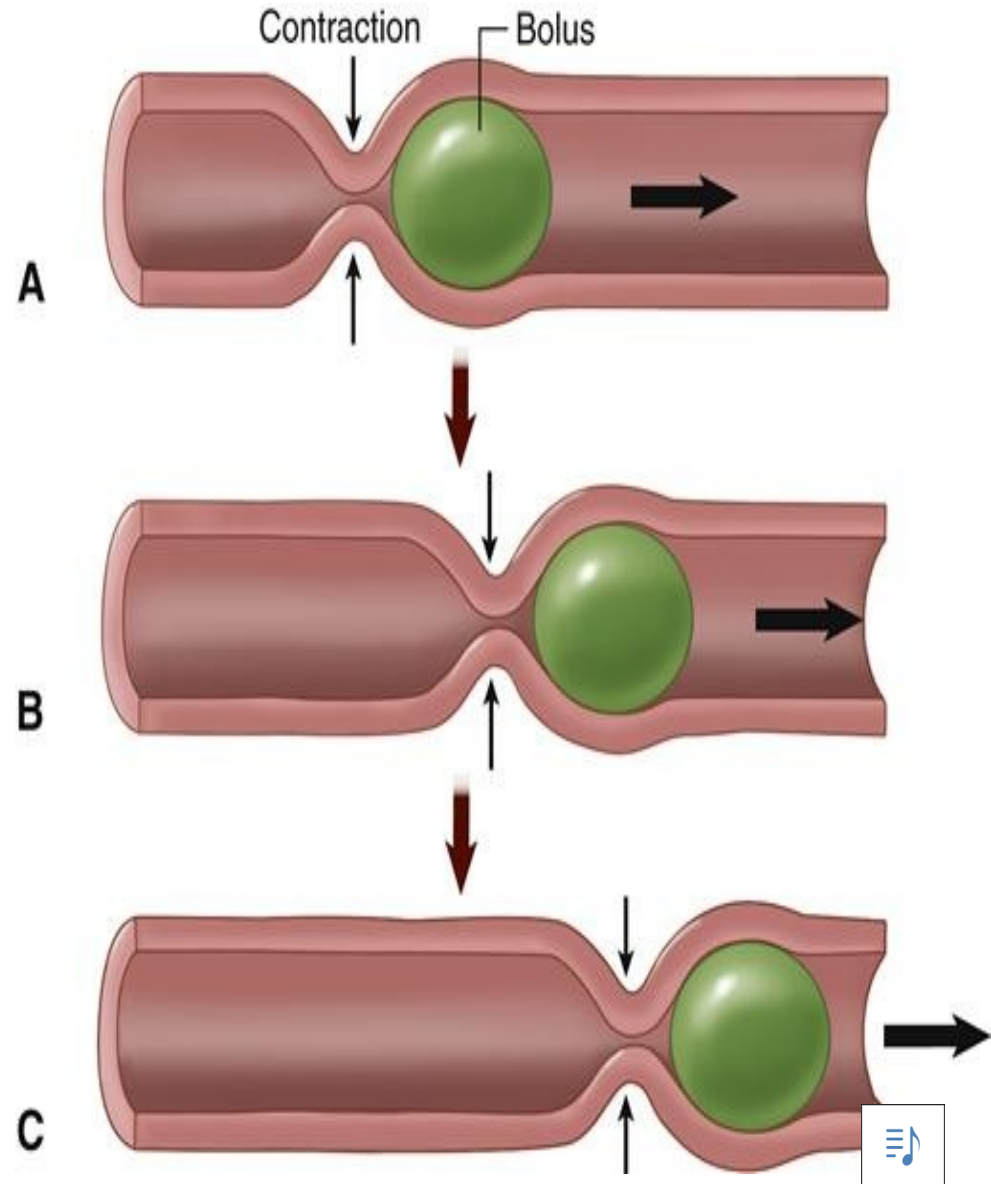
Motility (1)

Propulsive movements:

Peristalsis is a **reflex** - response that is initiated when the gut wall is stretched by the contents of the lumen

The stretch initiates a * **circular contraction** (contractile ring) **behind** the stimulus and an area of **relaxation** infront of it

The wave of * **contraction** then moves in an oral to



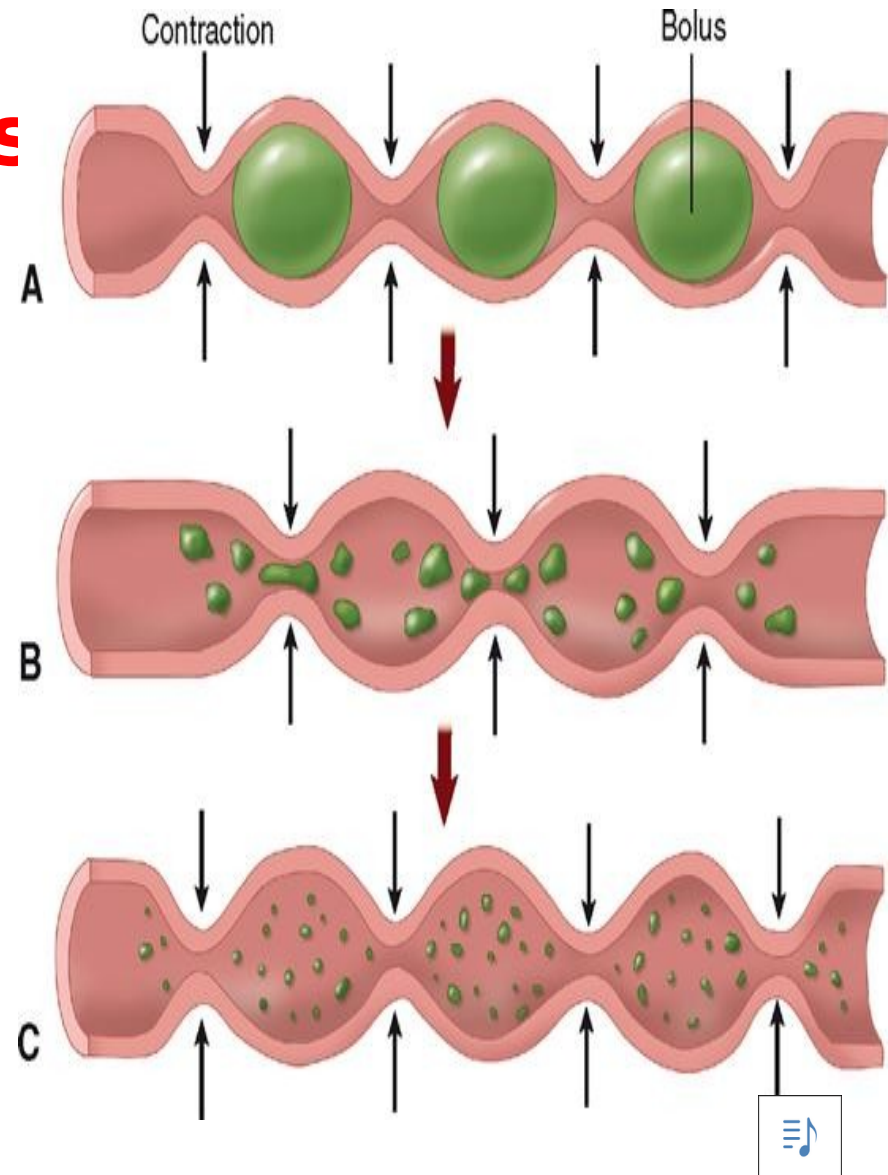
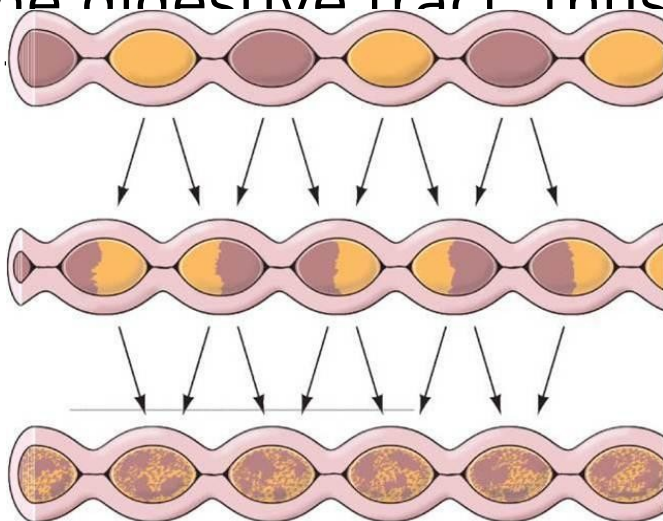
Motility (1)

:Mixing movements

;Have 2 functions

mix food with digestive -
enzymes, thus promote
.digestion

make food come in **contact** -
with the absorbing surfaces of
the digestive tract, thus



Note:

- Motility of digestive tract is accomplished by contraction of the **smooth muscles** within the walls, which is under **involuntary control**, except both **oral and anal ends of the** tract (mouth, pharynx, early part of esophagus and external anal sphincter), which contain **skeletal muscles**, are under **voluntary control**.
- Therefore, **the acts of chewing, swallowing and defecation have voluntary components.**



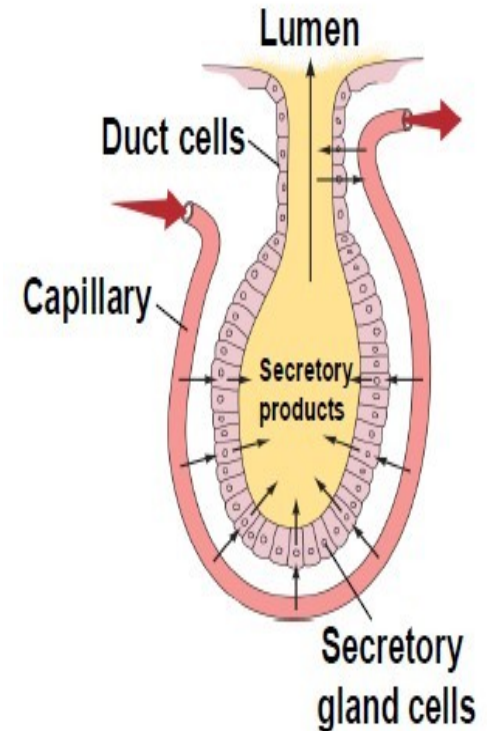
:Secretion (2

:Each digestive secretion consists of -

- **Water**
- **Inorganic** constituents e.g. electrolytes.
- **Organic** constituents e.g. enzymes, bile salts, mucus.

✓ Source: extract from the plasma.

✓ Fate: reabsorbed back into the blood after their participation in digestion.



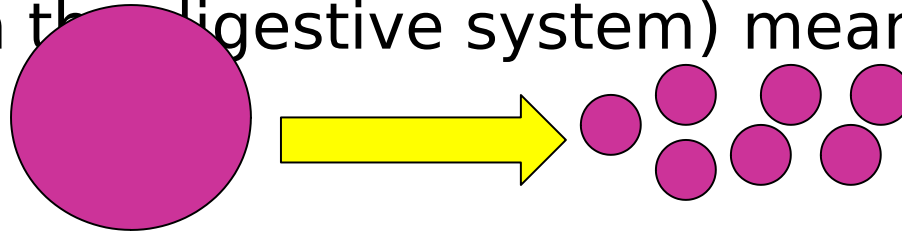
Failure to reabsorb digestive secretions *
because of vomiting or diarrhea, leads to loss of
these fluid and thus decreases plasma volume**



:Digestion (3

:Definition

Breakdown of large food molecules (carbohydrates, proteins and fats) into simple absorbable units (glucose, amino acids & fatty acids) by both mechanical and chemical (by the enzymes produced ..within the digestive system) means



:Types

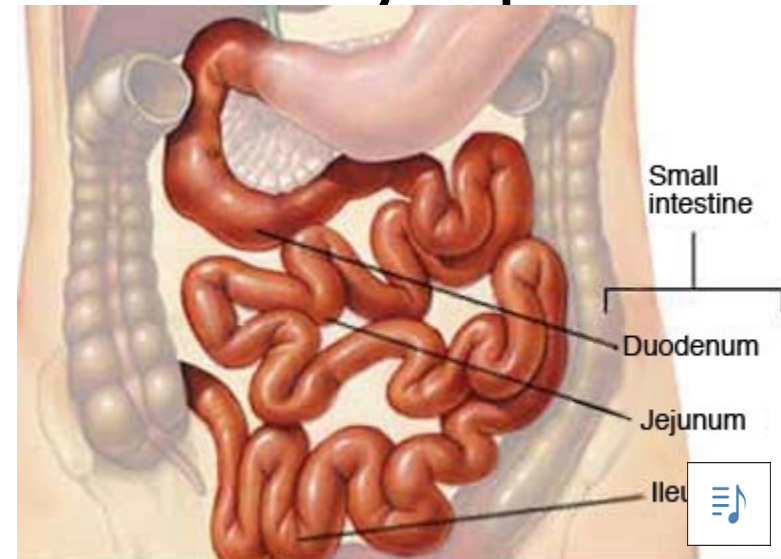
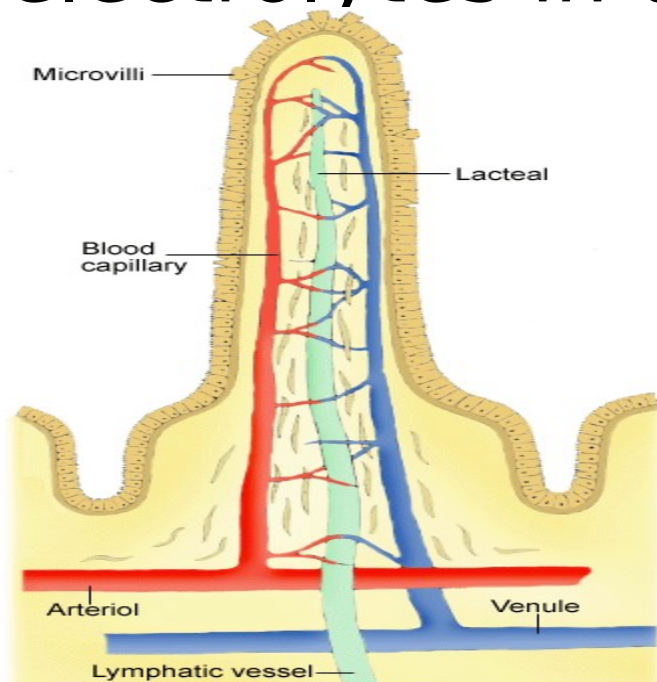
**Mechanical
digestion**

**Chemical
digestion**



Most absorption occurs in the **small intestine**

Small absorbable units that result -
from digestion, in addition to H_2O and
electrolytes in digestive tract lumen →
→ to blood and lymph

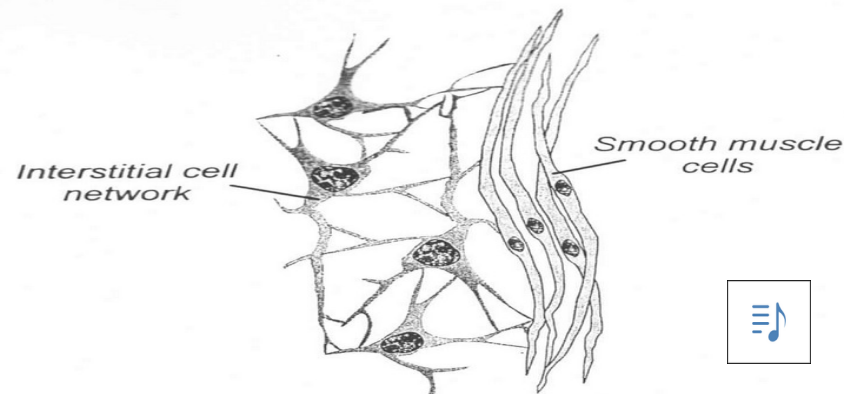
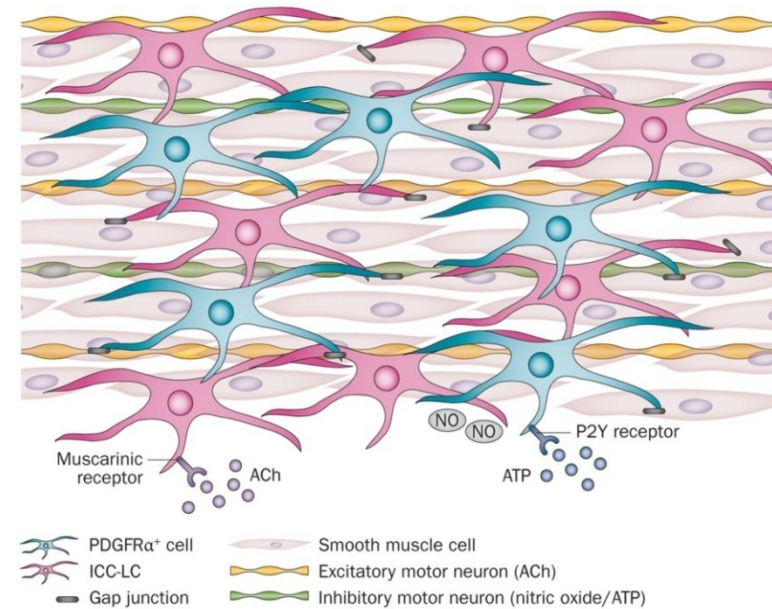


Control mechanisms of digestive :Processes

- .Autonomous smooth muscle function (1
- Intrinsic nerve plexuses (enteric nervous (2
.system)
- .Extrinsic nerves (autonomic nervous system) (3
- .Gastrointestinal hormones (4

Autonomous smooth (1 :muscle function

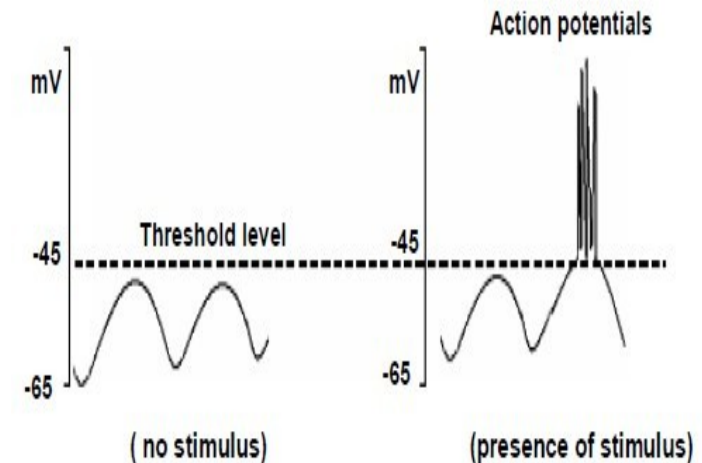
- Like **self excitable** cardiac muscle cells, some smooth muscle cells are **pace-maker (pace-setter) cells**.
- called **interstitial cells of Cajal**.
- Located between the longitudinal and circular muscle layers.
- **Non-contractile** cells
- Do not have a constant resting membrane



Autonomous smooth (1 :muscle function

The slow-wave potentials = basic electrical rhythm (BER):

- ✓ Are not action potentials.
- ✓ Are spontaneous, rhythmic, wave-like changes in the membrane potential (so called slow-wave potentials). Cyclically, bring the membrane potential closer to or farther from threshold potential.
- ✓ Might result from slow undulation of the pumping activity of the $\text{Na}^+\text{-K}^+$ pump.
- ✓ Do not directly induce muscle contraction because they do not cause Ca^{2+} to enter the smooth muscle fiber.



Slow wave potentials of GIT smooth muscle

- ✓ If the wave's peak reaches threshold, a

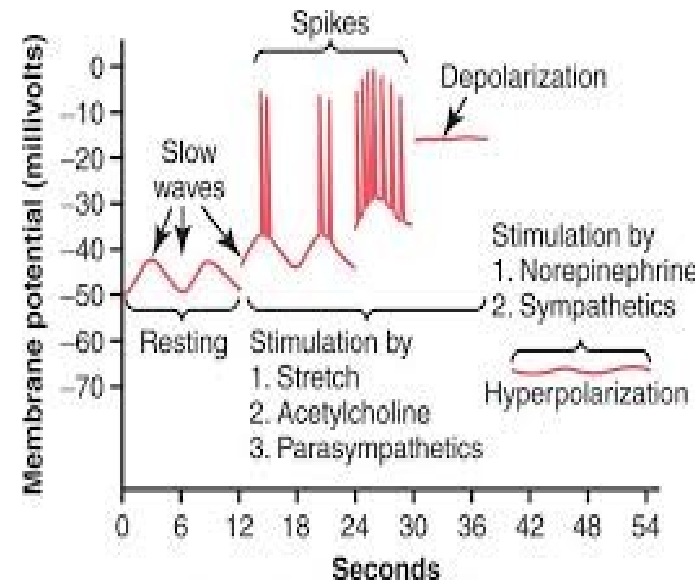


Factors influencing the slow-wave

potentials
mechanical, nervous and
hormonal factors

presence of food in the *
digestive tract

- stimulates mechanical, nervous and .hormonal pathways
- peak of the slow-wave potential
 - reaches threshold
- action potentials at the peak
 - followed by muscle contraction



Hall, Guyton and Hall Textbook of Medical Physiology, 12th Edition
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:When no food is present *

- the peak of the slow-wave potential
 - does not reach threshold
 - □ no action potentials
 - □ no muscle contraction



Electromechanical activity

:Rate of muscle contraction

Depends on the inherent rate -
of slow-wave potential in each
:organ

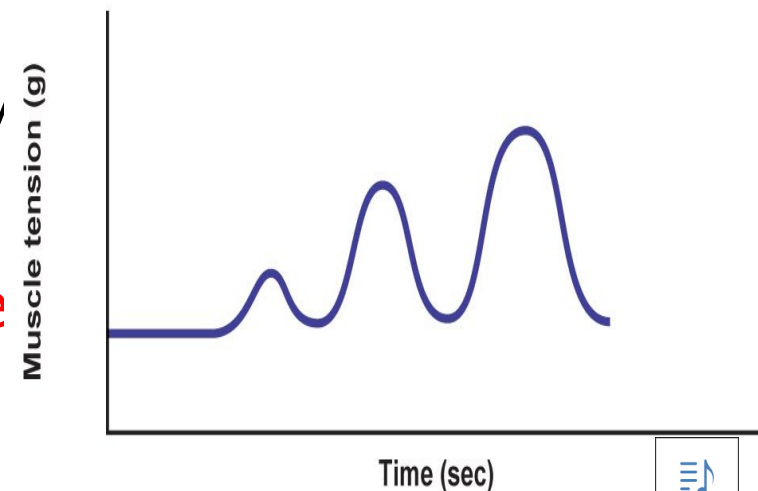
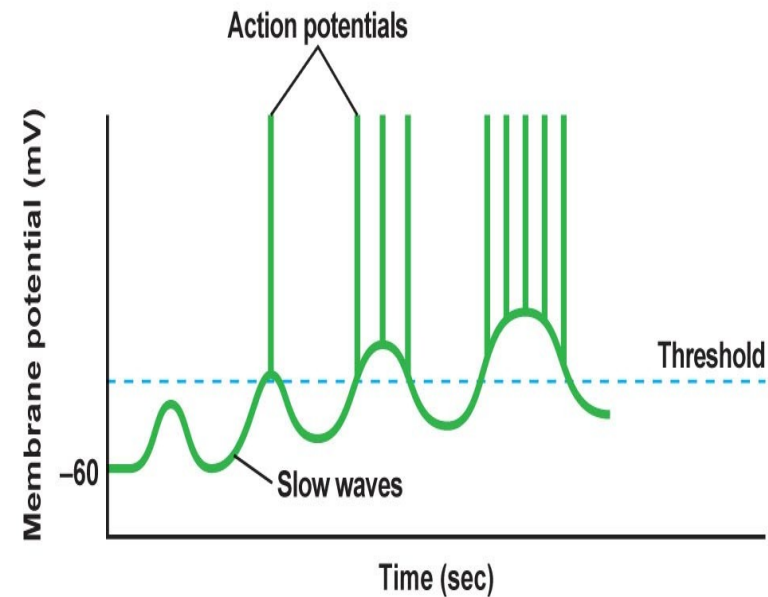
in stomach : 3 waves / min-

in duodenum : 12 waves / min-

in ileum : 9 waves / min-

in cecum : 2 waves / min-

in sigmoid colon : 6 waves / min-



Thus, in the small intestine there is descending gradient in BER frequency while in the colon there is ascending .gradient

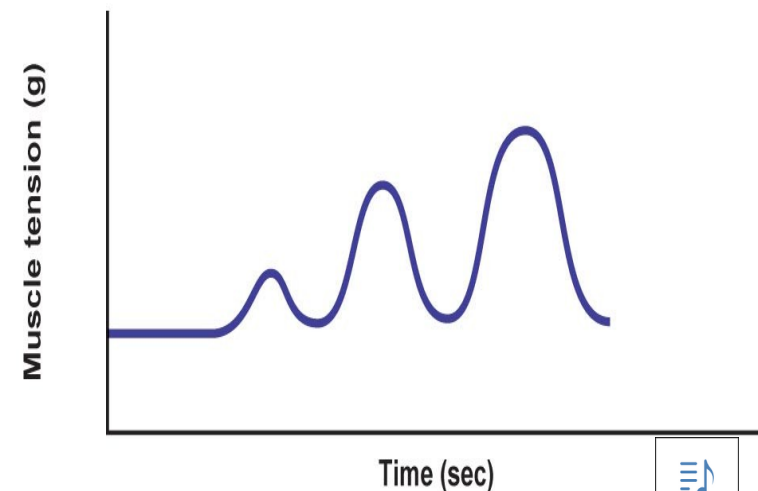
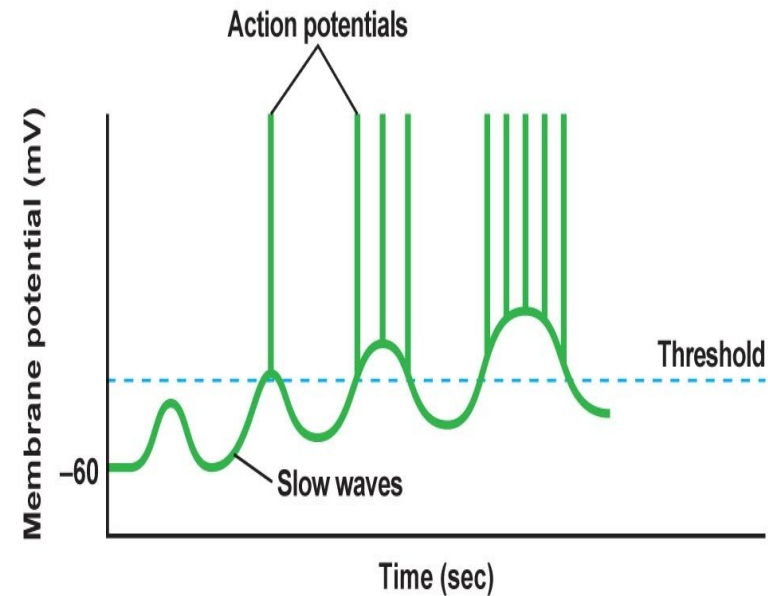
Function of BER is to coordinate the motor activity, as contraction occurs only at the .depolarization part of the wave

Electromechanical activity

Intensity of muscle * :contraction

- Depends on the number of action potentials triggered at each peak, because increase number of action potentials causes:

➤ Increase in **cytosolic Ca^{2+} concentration** → increase in cross-bridge activity → stronger contraction.



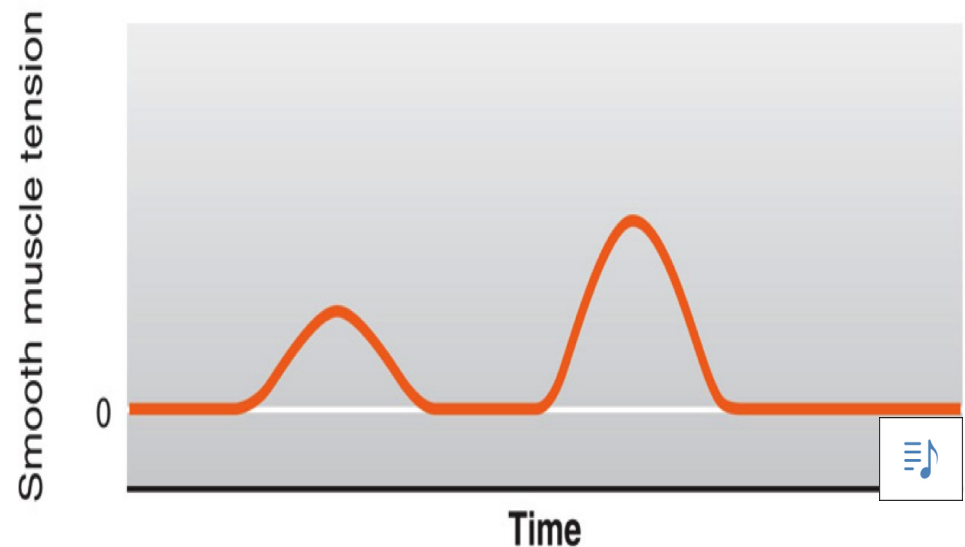
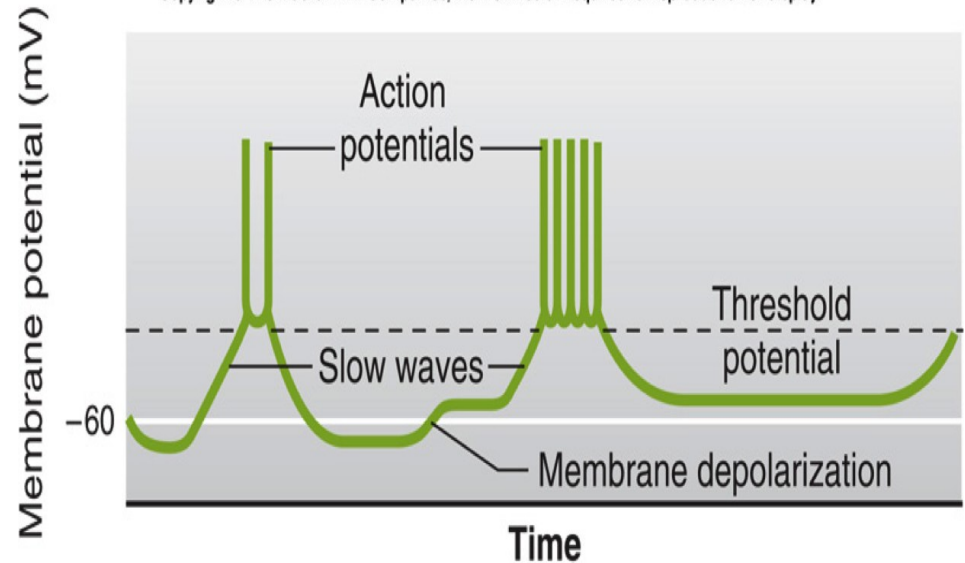
Electromechanical activity

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:In summary

The inherent **rate of***** **slow-wave potentials** in each organ determines the **number of** **contraction** in the .organ

The **number of***** **action potentials** at each peak determines **intensity of** **contraction**



Electromechanical activity

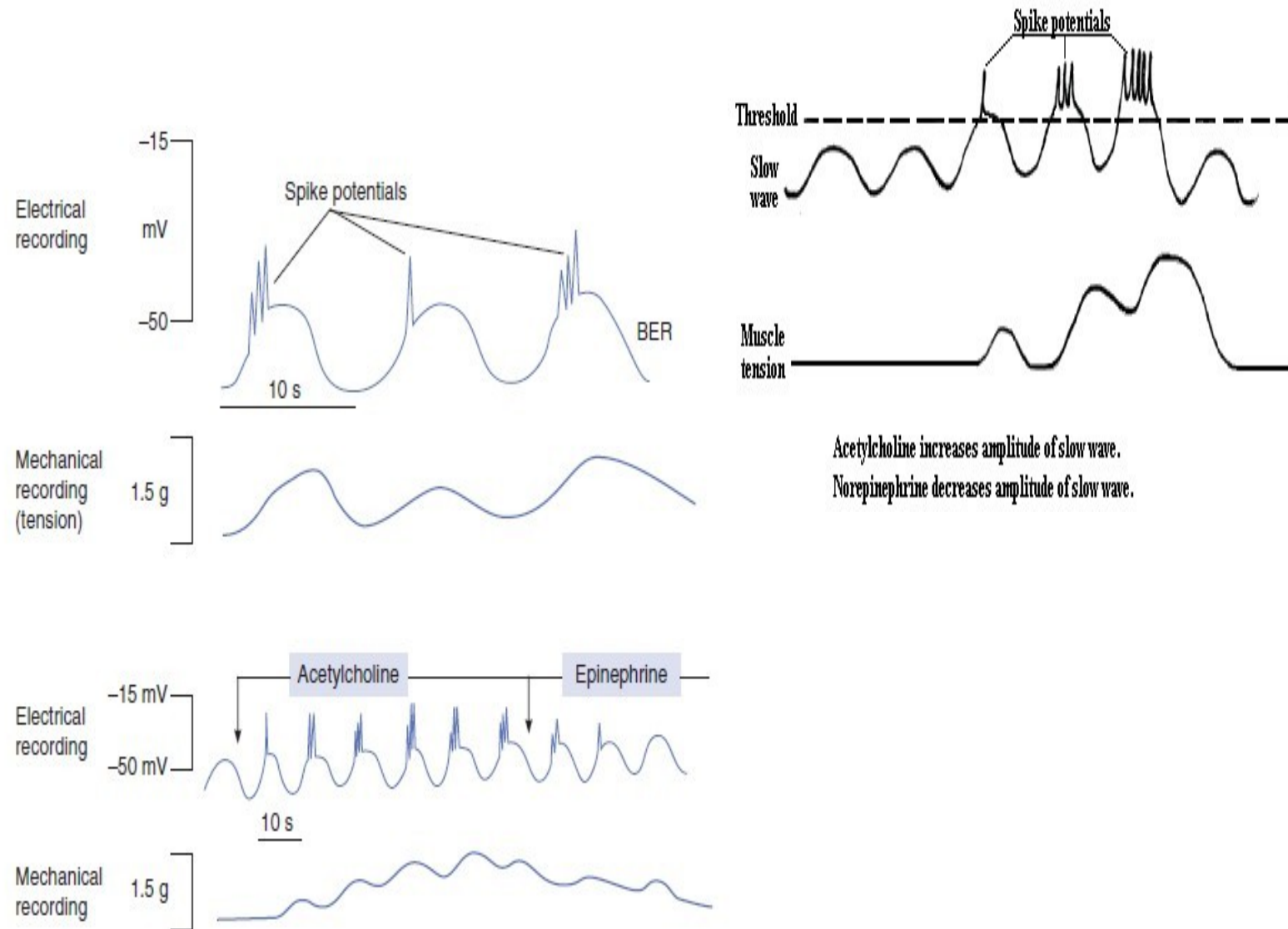
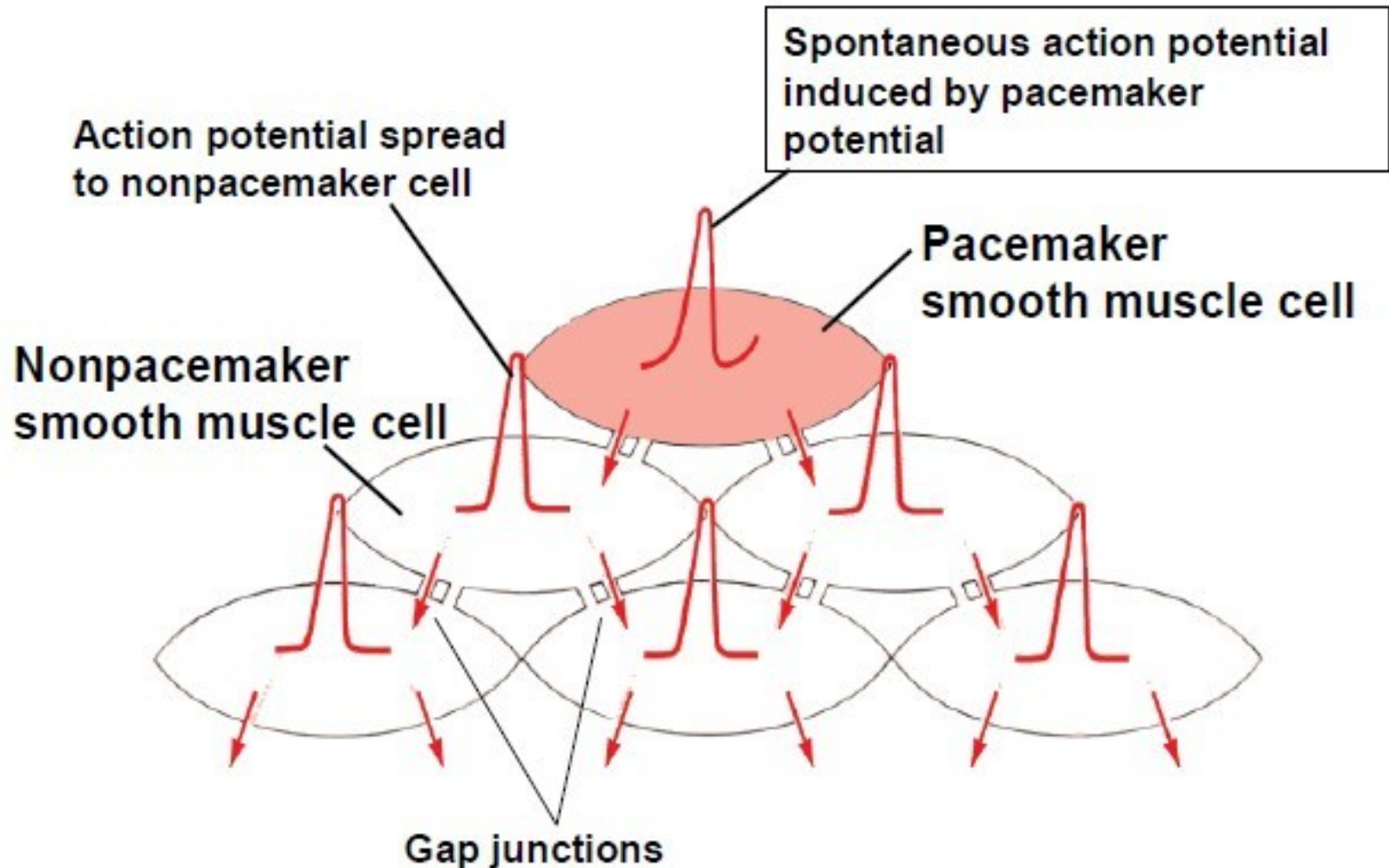


FIGURE 27-2 Basic electrical rhythm (BER) of gastrointestinal smooth muscle. **Top:** Morphology, and relation to muscle contraction. **Bottom:** Stimulatory effect of acetylcholine and inhibitory effect of epinephrine. (Modified and reproduced with permission from Chang EB, Sitrin MD, Black DD: *Gastrointestinal, Hepatobiliary, and Nutritional Physiology*. Lippincott-Raven, 1996.)



Functional syncytium of the GIT smooth :muscle

GAP JUNCTIONS



Functional syncytium of GIT smooth muscle



Control mechanisms of digestive processes (Quiz)



Slow-wave potentials (basic electrical rhythm) in intestinal smooth muscle cells are

- .a- Action potentials
- .b- Phasic contractions
- .c- Tonic contractions
- .d- Oscillating resting membrane potentials
- e- Oscillating release of cholecystokinin
(CCK)



Intrinsic nerve plexuses (2 (enteric nervous system))

Are interconnecting network of nerve cells -
. (neurons)

; Consist of: **2** plexuses -

**a) Myenteric (Auerbach's)
:plexus**

located between the longitudinal and circular smooth muscle layers and concerned with
. control of **GIT motility**

**b) Submucous (Meissner's)
:plexus**

located in the submucosa and concerned
. with control of **GIT secretion**

Their activity is influenced by -
. extrinsic nerves

Coordinate **local** activity within the -
. digestive tract

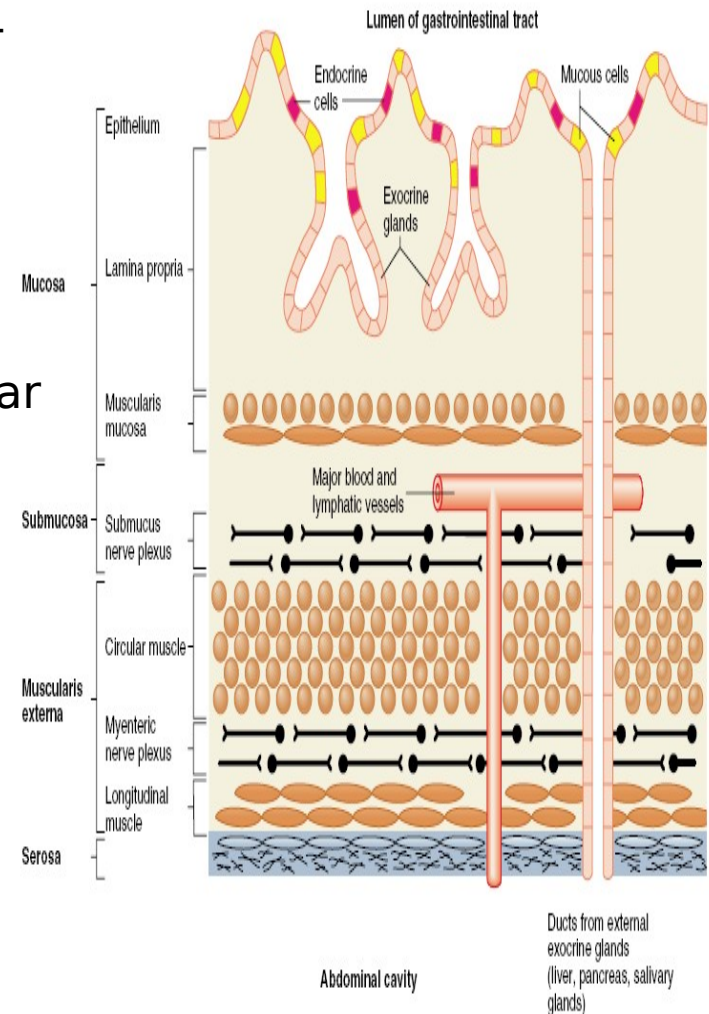


FIGURE 17-6

Structure of the gastrointestinal wall in longitudinal section. Not shown are the smaller blood vessels and lymphatics, connections between the two nerve plexuses, and neural terminations on muscles, glands and epithelium.



Intrinsic nerve plexuses (2 (enteric nervous system)

Types of neurons in the intrinsic :plexuses

- a) Input neurons:** **sensory** neurons, have receptors that
.respond to specific local stimuli in the digestive tract
- b) Interneurons:** **link** between the input and output neurons
- :c) Output neurons**
 - .**motor** neurons: innervate the smooth muscle cells*
 - .**secretory** neurons: innervate exocrine and endocrine cells*
 - Output neurons are either :
 - .**excitatory**: e.g. secrete acetylcholine □ contraction
 - inhibitory**: e.g. secrete nitric oxide (NO) and
 - .**vasoactive intestinal peptide (VIP)** □ relaxation



Extrinsic nerves (3)

They are the autonomic nerves (sympathetic and -
:parasympathetic) that innervate the various digestive organs

**They influence digestive tract motility and -
:secretion by 3 ways**

- .□ Direct effect on the smooth muscle and glands
- .□ Altering the activity of the intrinsic
- .□ Altering the level of GI hormones

:Function -

Sympathetic

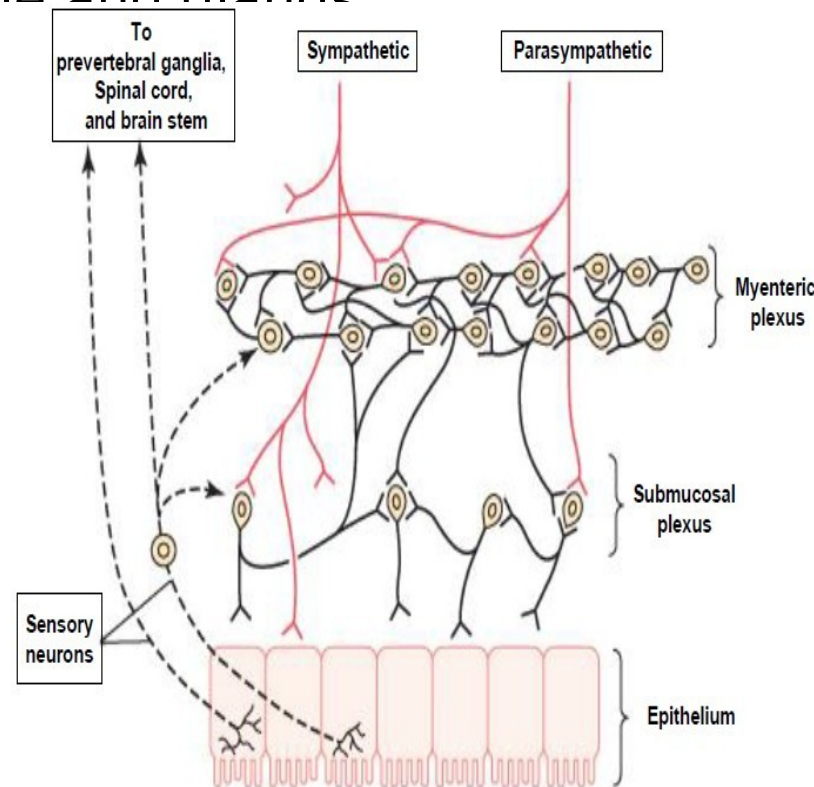
Dominates in
.stressful situation

Inhibits digestive
tract motility and
secretion
(sympathetic
relaxes the wall
and contracts the
.sphincters)

Parasympathetic

inates in quiet,
relaxed
.situation

Stimulates
digestive tract
motility and
secretion
(parasympathetic
contracts the wall
and relaxes the
.sphincters)

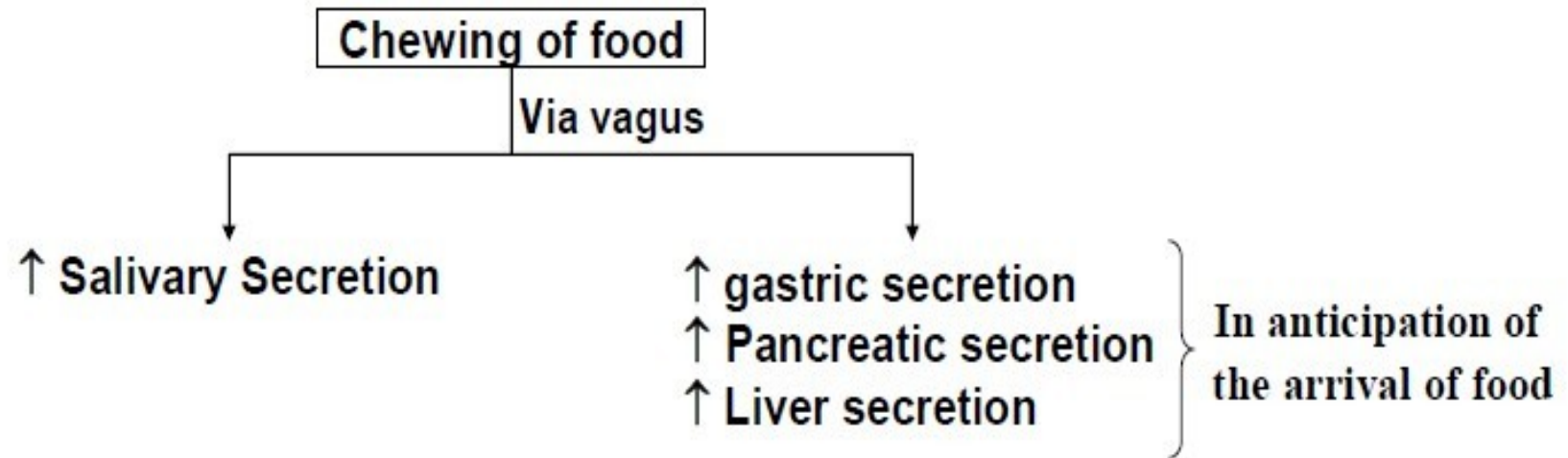


Neural control of the gut wall, showing (1) the myenteric and submucosal plexuses; (2) extrinsic control of these plexuses by the sympathetic and parasympathetic nervous systems; and (3) sensory fibers passing from the luminal epithelium and gut wall through the myenteric plexuses, then to the prevertebral ganglia of the spinal cord and directly to the spinal cord and brain stem (dashed fibers).

Importance of the extrinsic innervation of the :digestive tract

a) Coordinate the activity between different :regions of the digestive system

e.g., the act of chewing reflexly increases not only the salivary secretion but also stomach, pancreas and liver secretion via vagal .n



b) Make digestive system respond to external :stimuli

e.g., sight or smell of food, via vagus stimulates gastric, pancreatic and .liver secretions

Notice that: External influences act only through extrinsic autonomic nerve (sympathetic and parasympathetic)



Control mechanisms of digestive processes (Quiz)



Parasympathetic stimulation increases gastrointestinal motility and sympathetic stimulation decreases it. The autonomic nervous system controls gut motility by changing which of the following:-

- .a- Gastrin secretion**
- .b- Pacemaker discharge frequency**
- .c- Secretin secretion**
- .d- Slow wave frequency**
- .e- Spike potential frequency**



Gastrointestinal reflexes

:Short reflexes***

- They are local reflexes that occur **entirely within GIT wall**, via intrinsic plexuses (from GIT receptors to intrinsic nerve plexuses and back to GIT wall).

They regulate motility and secretion in -
.a local area of the digestive tract

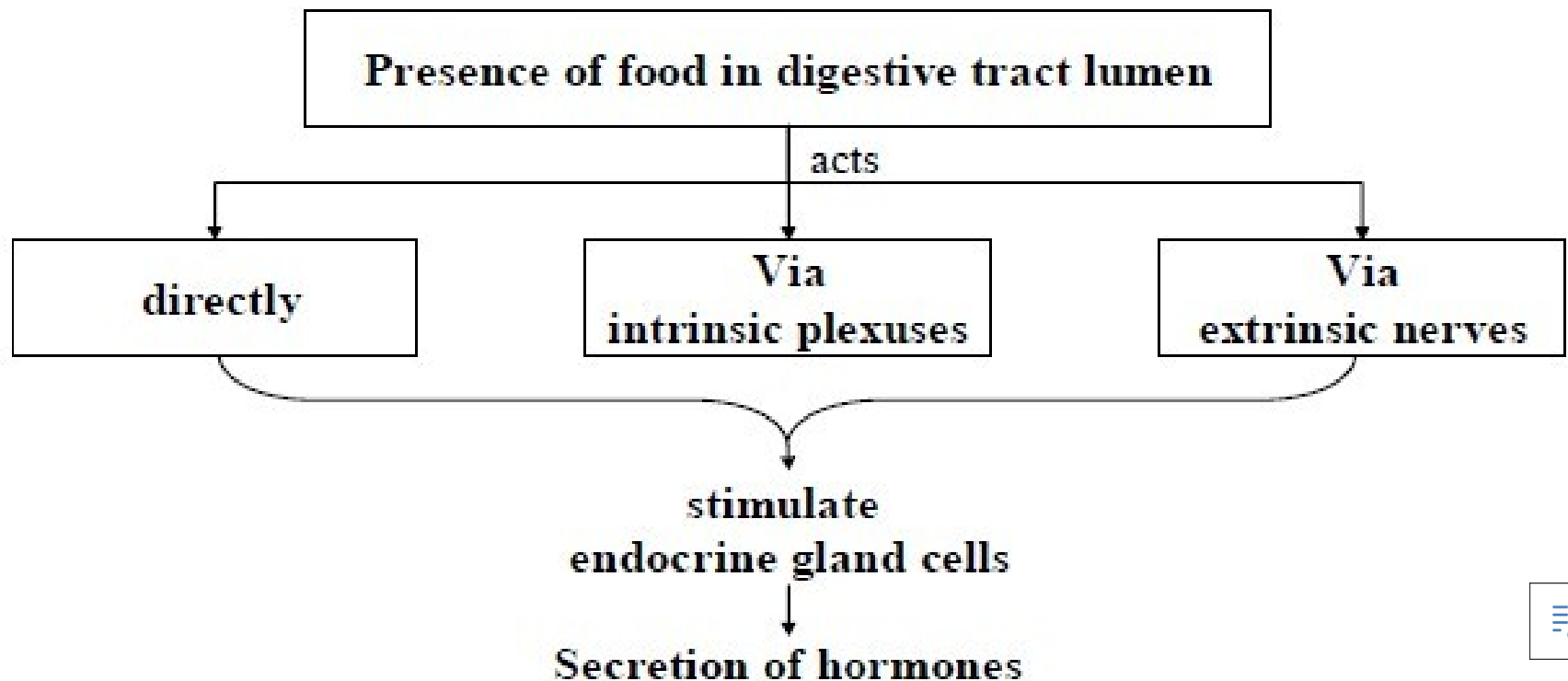
:Long reflexes***

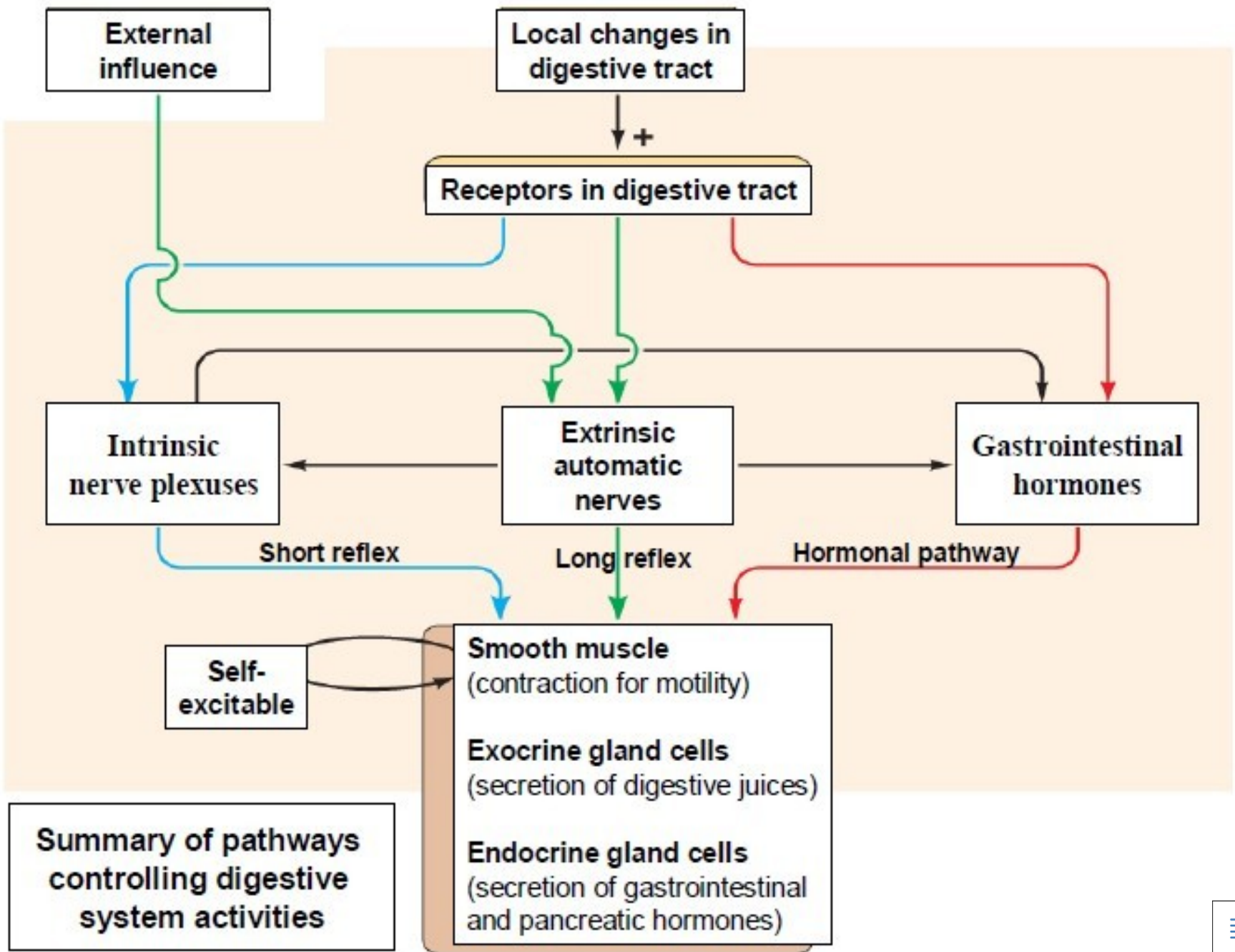
They extend from GIT wall to **spinal cord**, or to **brain stem** and then back to



Gastrointestinal hormones (4

Released by endocrine gland cells in the mucosa of digestive tract, and then carried through blood to other areas of the digestive tract, where they exert either excitatory or inhibitory effects on GI motility and secretion.





Control mechanisms of digestive processes (Quiz)



Concerning control of digestive function:

- a- short reflexes coordinate the activity between different .regions of digestive system
- b- myenteric nerve plexuses mainly regulate the motility .of the digestive tract
- c- parasympathetic activation relaxes the digestive tract .wall
- d- extrinsic nerves act only via modifying the activity of .the intrinsic plexuses
- e- sympathetic activation increase motility of digestive .tract



Summary



- Slow waves in gastrointestinal smooth muscle cells are spontaneous cyclic alteration of the membrane potential. Action potentials are fired if the membrane potential reaches threshold as a result of a slow wave. Thus the frequency of slow waves determines the frequency of action potentials and, consequently, the frequency of contractions. While the number of action potentials generated determines the force of contractions.
- The gastrointestinal tract is innervated by both the parasympathetic and sympathetic nervous systems, which converge on the intrinsic nervous system in the myenteric and submucosal plexuses.
- Gastrointestinal peptides are secreted by cells of the gastrointestinal tract and include the hormones gastrin, CCK, secretin, and GIP, which are released into the circulation; the paracrines somatostatin and histamine, which act locally; and neurocrines VIP, which are released from nerves.

Lecture Quiz



Q: **Define** Basal Electric Rhythm (BER),
what is its underlying **cause**, and
?factors affecting it



SUGGESTED TEXTBOOKS



1. Ganong's review of medical physiology

25th edition

2. Sherwood 9th edition



THANK YOU

